

## What is Claimed:

1                   1. A composition for treating the surface of a ferrous metal, the  
2 composition comprising:

3                   a) at least one of aluminum sulfate and an aluminum sulfate  
4                   precursor;

5                   b) at least one of boric acid and a boric acid precursor; and

6                   c) at least one of a polycarboxylic acid and a polycarboxylic acid  
7                   precursor.

1                   2. The composition of claim 1, wherein said at least one of a  
2 polycarboxylic acid and a polycarboxylic acid precursor comprises at least one of  
3 oxalic acid and a water-soluble salt of oxalic acid.

1                   3. The composition of claim 2 further comprising a second  
2 polycarboxylic acid, wherein said second polycarboxylic acid comprises at least one of  
3 adipic acid and azelaic acid.

1                   4. The composition of claim 1, wherein said at least one of a  
2 polycarboxylic acid and a polycarboxylic acid precursor comprises at least one of  
3 citric acid and a water-soluble salt of citric acid.

1                   5. The composition of claim 4 further comprising a second  
2 polycarboxylic acid, wherein said second polycarboxylic acid comprises at least one of  
3 adipic acid and azelaic acid.

1                   6.       The composition of claim 1 further comprising a polyol.

1                   7.       The composition of claim 6, wherein said polyol comprises at  
2       least one of trimethylolpropane, pentaerythritol, and dipentaerythritol.

1                   8.       The composition of claim 6, wherein said polyol comprises at  
2       least one of trimethylolpropane and pentaerythritol.

1                   9.       The composition of claim 1 further comprising at least one of L-  
2       aspartic acid and D-aspartic acid.

1                   10.      The composition of claim 1 further comprising glutamic acid.

1                   11.      The composition of claim 1, wherein said aluminum sulfate, said  
2       at least one of boric acid and a boric acid precursor, and said at least one of a  
3       polycarboxylic acid and a polycarboxylic acid precursor are present in the following  
4       amounts:

5                   a)      between about 40 wt.% and about 80 wt.% of aluminum  
6       sulfate;

7                   b)      between about 10 wt.% and about 20 wt.% total of at least one  
8       of boric acid and a boric acid precursor; and

9                   c)      between about 10 wt.% and about 20 wt.% total of at least one  
10      of a polycarboxylic acid and a polycarboxylic acid precursor.

1                   12. The composition of claim 11 further comprising:

2                   d) between about 5 wt.% and about 10 wt.% of citric acid;

3                   e) between about 2 wt.% and about 5 wt.% of pentaerythritol;

4                   f) between about 2 wt.% and about 5 wt.% of adipic acid; and

5                   g) between about 1 wt.% and about 3 wt.% of L-aspartic acid.

1                   13. A composition for treating the surface of a ferrous metal, the  
2 composition comprising:

3                   a) between about 50 wt.% and about 70 wt.% of aluminum  
4                   sulfate;

5                   b) between about 10 wt.% and about 15 wt.% of boric acid;

6                   c) between about 5 wt.% and about 15 wt.% of oxalic acid;

7                   d) between about 2 wt.% and about 7 wt.% of citric acid;

8                   e) between about 2 wt.% and about 7 wt.% of adipic acid;

9                   f) between about 1 wt.% and about 5 wt.% of pentaerythritol;

10                  g) between about 1 wt.% and about 5 wt.% of  
11                  trimethylolpropane;

12                   h)     between about 0.5 wt.% and about 2 wt.% of azelaic acid; and

13                   i)     between about 1 wt.% and about 5 wt.% of L-aspartic acid, D-

14                   aspartic acid, or a mixture thereof.

1                   14.    A method for treating the surface of a ferrous metal, comprising

2    contacting the surface of a ferrous metal with an aqueous mixture comprising:

3                   a)     aluminum sulfate;

4                   b)     boric acid; and

5                   c)     a polycarboxylic acid.

1                   15.    The method of claim 14 further comprising bringing said

2    aqueous mixture to a temperature between about 150°F and about 210°F.

1                   16.    The method of claim 14 wherein the pH of said aqueous mixture

2    is between about 1 and about 4.

1                   17.    The method of claim 14, wherein the contacting step comprises

2    contacting the surface of the ferrous metal with the aqueous mixture for a period of

3    time between about 1 minute and about 15 minutes.

1                   18.    The method of claim 17, wherein said period of time is between

2    about 2 minutes and about 10 minutes.

1                   19. The method of claim 14, wherein said ferrous metal is a low-  
2 carbon steel, and wherein the contacting step comprises contacting the surface of the  
3 ferrous metal with the aqueous mixture at a temperature between about 185°F and  
4 about 200°F.

1                   20. The method of claim 14, wherein said ferrous metal is a  
2 medium-carbon steel, and wherein the contacting step comprises contacting the  
3 surface of the ferrous metal with the aqueous mixture at a temperature between  
4 about 170°F and about 200°F.

1                   21. The method of claim 14, wherein said ferrous metal is a high-  
2 carbon steel, and wherein the contacting step comprises contacting the surface of the  
3 ferrous metal with the aqueous mixture at a temperature between about 160°F and  
4 about 200°F.

1                   22. The method of claim 14, wherein said aqueous mixture further  
2 comprises at least one of L-aspartic acid and D-aspartic acid.

1                   23. The method of claim 14, wherein said polycarboxylic acid  
2 comprises at least one of oxalic acid and citric acid.

1                   24. The method of claim 14, wherein said aqueous mixture further  
2 comprises a polyol.

1                   25. The method of claim 14, wherein said aqueous mixture further  
2 comprises at least one of adipic acid and azelaic acid.

1                   26. A ferrous metal treated by the method of claim 14.

1                   27. An aqueous mixture for treating the surface of a ferrous metal,  
2   the mixture comprising:

3                   a) aluminum sulfate;  
4                   b) boric acid; and  
5                   c) a polycarboxylic acid.

1                   28. The aqueous mixture of claim 27 having a pH between about 1  
2   and about 4.

1                   29. The aqueous mixture of claim 27, wherein said polycarboxylic  
2   acid comprises oxalic acid.

1                   30. The aqueous mixture of claim 29 further comprising a second  
2   polycarboxylic acid, wherein said second polycarboxylic acid comprises at least one of  
3   adipic acid and azelaic acid.

1                   31. The aqueous mixture of claim 27, wherein said polycarboxylic  
2   acid comprises citric acid.

1                   32. The aqueous mixture of claim 31 further comprising a second  
2   polycarboxylic acid, wherein said second polycarboxylic acid comprises at least one of  
3   adipic acid and azelaic acid.

1                   33. The aqueous mixture of claim 27 further comprising a polyol.

1                   34. The aqueous mixture of claim 33, wherein said polyol comprises  
2                   at least one of trimethylolpropane, pentaerythritol, and dipentaerythritol.

1                   35. The aqueous mixture of claim 33, wherein said polyol comprises  
2                   at least one of trimethylolpropane and pentaerythritol.

1                   36. The aqueous mixture of claim 27 further comprising at least  
2                   one of L-aspartic acid and D-aspartic acid.

1                   37. The aqueous mixture of claim 27 further comprising glutamic  
2                   acid.

1                   38. The aqueous mixture of claim 27, wherein said aluminum  
2                   sulfate, said boric acid, and said polycarboxylic acid are present in the following  
3                   relative amounts, exclusive of added water:

4                   a) between about 40 wt.% and about 80 wt.% of aluminum  
5                   sulfate;

6                   b) between about 10 wt.% and about 20 wt.% of boric acid and a  
7                   boric acid; and

8                   c) between about 10 wt.% and about 20 wt.% total of a  
9                   polycarboxylic acid.

1                   39. The aqueous mixture of claim 38 further comprising:

2                   d)    between about 5 wt.% and about 10 wt.% of citric acid;

3                   e)    between about 2 wt.% and about 5 wt.% of pentaerythritol;

4                   f)    between about 2 wt.% and about 5 wt.% of adipic acid; and

5                   g)    between about 1 wt.% and about 3 wt.% of L-aspartic acid.

1                   40. An aqueous mixture for treating the surface of a ferrous metal,  
2 the composition comprising the following materials in the following relative amounts,  
3 exclusive of added water:

- 4 a) between about 50 wt.% and about 70 wt.% of aluminum
- 5 sulfate;
- 6 b) between about 10 wt.% and about 15 wt.% of boric acid;
- 7 c) between about 5 wt.% and about 15 wt.% of oxalic acid;
- 8 d) between about 2 wt.% and about 7 wt.% of citric acid;
- 9 e) between about 2 wt.% and about 7 wt.% of adipic acid;
- 10 f) between about 1 wt.% and about 5 wt.% of pentaerythritol;
- 11 g) between about 1 wt.% and about 5 wt.% of
- 12 trimethylolpropane;
- 13 h) between about 0.5 wt.% and about 2 wt.% of azelaic acid; and

14                   i)     between about 1 wt.% and about 5 wt.% of L-aspartic acid, D-  
15                   aspartic acid, or a mixture thereof.

1                   41.    A method for making an aqueous mixture for treating the  
2                   surface of a ferrous metal, the method comprising mixing together in any sequence  
3                   the following materials:

4                   a)     at least one of aluminum sulfate and an aluminum sulfate  
5                   precursor;

6                   b)     at least one of boric acid and a boric acid precursor;

7                   c)     at least one of a polycarboxylic acid and a polycarboxylic acid  
8                   precursor; and

9                   d)     water.

10                  42.    The method of claim 41 further comprising bringing the pH of  
the aqueous mixture to between about 1 and about 4.